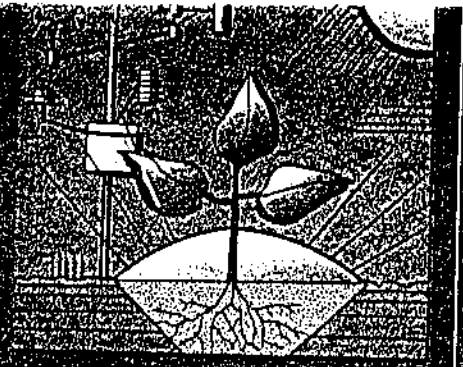

EVAPOTRANSPIRATION AND IRRIGATION SCHEDULING

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Texas North Plains PET Network

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ABSTRACT

A potential evapotranspiration (PET) network has been developed and implemented within the northern Texas High Plains. The network represents approximately 1.6 million ha of irrigated agriculture. The network system utilizes automated data acquisition units to log meteorological data and report it on an hourly basis at multiple sites representative of different commodities grown within a 30 county area. Interrogation of the units is by phone communication. The system automatically computes and dispatches faxes to each subscriber in the early morning hours indicating estimates of PET, growing degree day units, physiological growth stage and daily and seasonal water use from the previous day(s). In addition, the system uploads to a network bulletin board for modem access by individuals requiring more detailed data than provided within the faxes. Illustrations of each daily output are provided.

All PET computations are based on a modified Penman-Monteith ET equation. Crop coefficients for corn, grain sorghum and wheat were calibrated with the large, weighing lysimeters at Bushland, TX, and use well-watered grass as a reference crop. PET, physiological growth stages and growing degree heat units are currently provided for corn, sorghum, cotton and wheat. Complete peanut and sugarbeet parameters are still being compiled. Planned enhancements to the system include improved disease and insect development models.

Keywords: Automated weather network, Irrigation management.

INTRODUCTION

Irrigated agriculture accounts for approximately 60% of the water use in Texas (Texas Water Facts, 1991). Accordingly, a large part of the irrigated agriculture in the state using groundwater is in the Texas High Plains, accounting for over 85% of the water use within this area. This irrigated area is approximately 1.6 million ha. The major intensive irrigated area continues to be in the northern region of the Texas Panhandle and is supported by the number of wells being drilled or reworked, the availability of an adequate saturated thickness, although deep, and the continuing installation of center pivot sprinkler systems in the region.

While the efficiency of these sprinkler systems can be very good, especially when designed with LEPA (Lyle & Bordovsky, 1981) or a LESA (Low Elevation, Sprinkler Applied) irrigation package, irrigators generally tend to over irrigate when compared to actual crop requirements. This is especially true for irrigated corn which is a major commodity within the area due to the intensive, major confined animal feeding industry. Additionaliy, winter wheat is grown for fall and winter grazing of stocker cattle before their placement into feedlots. Accordingly, there existed a need for daily ET data for numerous crops grown within this intensive northern Texas agricultural region 1) to efficiently utilize the declining groundwater supplies through efficient irrigation practice, and 2) to provide accurate water use data to these productive growers. The southern Texas High Plains currently utilize the South Plains PET Network for predicting ET (Seymour, et al., 1994). The two networks present water use in significantly different formats to users.

The North Plains PET network has applications with deficit irrigation. In irrigation programs where full ET is not being met, a reference level can be related to full ET requirements whereby improved irrigation scheduling and water management can be implemented. The principal anticipated users of the network are: growers/irrigators/farm managers, production consultants, seed production representatives, agronomists, agricultural engineers, researchers, extension specialists, water district technicians, regulators, design engineers, city water personnel and golf course managers.

DEVELOPMENT AND IMPLEMENTATION

In 1995, a collaborative PET network was developed by Texas A&M University System's Texas Agricultural Experiment Station and Texas Agricultural Extension Service of Amarillo, Texas with the USDA's Agricultural Research Service at Bushland, Texas. In addition, assistance has been provided by the Panhandle Water District at Whitedeer, Texas, the North Plains Underground Water Conservation District at Dumas, Texas, The Texas Wheat Producers Association at Hereford, Texas and the Texas Corn Producers at Dimmitt, Texas.

Initially, operational and data constraints setforth by the development team consisted of the following:

1) Data must be accurate (scientifically based),
2) Data must be timely (daily),
3) Data must contain integrity (through scheduled maintenance),
4) Data must be calibrated (using large, lysimeter facility),
5) Data must be sustainable (utilize a fee based system), and
6) Units should meet proposed ASAE EP specifications for automated agricultural weather stations (Ley, et al., 1994).

All weather stations within the network use Campbell Scientific's Weather Watch 2000™ microloggers, data storage modules, modems and sensors. Each station measures the following data on a 6 second interval and outputs it on an hourly basis: soil temperatures at 50 and 150 mm depths, ambient air temperature (1.8m), dewpoint temperature, relative humidity, vapor pressure, vapor pressure deficit, solar radiation, wind speed (2m), wind direction, standard deviation of the wind direction, and precipitation. Several parameters indicating maximum and minimum and total values are reported in a daily summary. Rainfall intensity data is recorded for 15 minute intervals.

The weather stations are interrogated by telephone communication due to dependability required for the region which is susceptible to severe thundershower activity the majority of the growing season. Sequential automated computer to computer transfers occur for security and functionality purposes. All activities of the network are handled by PC computers. The operational series of events performed by the PC computers daily is as follows: wake up central PC computer, call weather stations, download data, check raw data sets, report errors, manipulate and process data sets, archive data sets, compute PET and respective ET utilizing a modified, Penman-Monteith equation for the appropriate crops as well as growing degree day and seasonal water use, run other model(s) such as insect development model(s), initiate fax

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calls, send faxes, transfer data and fax logs to backup PC computer, call remote bulletin board system (BBS), upload data and logs to bulletin board system and turn off central PC computer.

The network was initialized in 1995 with the beginning of the corn crop and followed with the grain sorghum and wheat crop. The corn and grain sorghum crops each had four planting dates with two hybrid maturities for which water use, growing degree day heat units and physiological growth stages were computed. Likewise, the wheat and cotton crops were computed for four planting dates of only one typical variety.

Implementation of the network was completed by mid April in 1995 with the six sites shown in Fig. 1. Each location was chosen to represent a specific irrigation area which was known to differ meteorologically from adjacent locations. In addition, sites were chosen at locations where they were to be supported by private and/or governmental entities as well as where there existed a sizable, potential irrigation user clientele. These criteria were critically addressed before implementation to enhance utilization of the network.

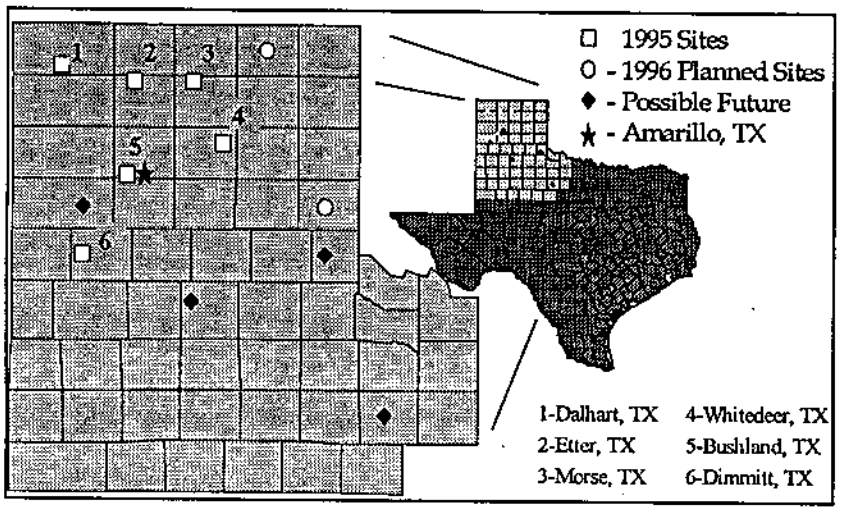

Figure 1. Current and planned Texas North Plains PET sites

DISSEMINATION OF OUTPUTS

The daily output of the network is available in two forms. The primary output is disseminated in the form of a fax to subscribers for the crops of the appropriate growing season at each location. The second means of dissemination of the network is through a computerized bulletin board system.

The fax output is illustrated in Fig. 2. The fax date chosen for this illustration corresponds to the last date for the corn crop in the 1995 season for the Etter, TX location. It should be noticed that the grain sorghum and wheat crops are also reported concurrently. The fax sheet contains PET based on well watered grass (Allen, et al., 1994) for the past three days. In addition, maximum and minimum air and soil temperatures at the 50 and 150 mm depths are displayed. Ten day minimum soil temperatures for both depths are also indicated. The sheet includes growing degree day heat units for the crops of cotton, grain sorghum, peanuts, corn, soybeans, sugarbeets and wheat. The next section contains information regarding ET information for each day, 3 day, 7 day and accumulated seasonal use for both a short and full

season variety of the respective crop for each of 4 planting dates. The information is related for each of the crops concurrently being grown for the time period.

The computerized bulletin board system contains hourly micrometeorological information for each day at each location with more detailed daily summary information than is provided in the fax output. A typical daily file containing the hourly and summary information

North Plains PET Network Weather Station, Etter, TX

Date	PET	Temperatures (F) ---Air-- Max	Min	--Soil-- 2in.	6in.	Prec. in.	Growing Degrees Days (F) Crn	Srg	Pnt	Cot	Soy	Bet	Wht
	in.												
09/29/95	.26	85	56	66	65	0.05	20	20	15	12	24	30	36
09/30/95	.19	71	46	65	65	0.00	11	11	8	6	13	19	27
10/01/95	.21	77	41	63	64	0.00	13	13	11	8	15	19	27
Ten day avg soil temps				63	63								

CORN		Early Season Variety					Long Season Variety				
Seed Date	Acc GDD	Grwth Stage	Day	3day	7day	Seas. in.	Grwth Stage	Day	3day	7day	Seas. in.
			-----in/d-----					-----in/d-----			
04/01	3130	Harvest	.00	.00	.00	32.2	Harvest	.00	.06	.10	36.9
04/15	3018	Harvest	.00	.00	.00	30.8	1/2 mat	.19	.20	.17	35.5
05/01	2910	Harvest	.00	.00	.00	30.1	1/2 mat	.19	.21	.19	33.8
05/15	2743	Blk lyr	.15	.15	.14	29.1	Dough	.25	.26	.23	31.3

SORGHUM		Early Season Variety					Long Season Variety				
Seed Date	Acc GDD	Grwth Stage	Day	3day	7day	Seas. in.	Grwth Stage	Day	3day	7day	Seas. in.
			-----in/d----					-----in/d----			
05/01	3171	Blk lyr	.18	.19	.17	27.6	H Dough	.19	.20	.17	27.1
05/15	3004	Blk lyr	.18	.19	.17	25.3	H Dough	.19	.20	.17	24.7
06/01	2797	Blk lyr	.18	.19	.17	23.1	H Dough	.19	.20	.18	22.4
06/15	2543	H Dough	.19	.20	.18	20.5	S Dough	.20	.21	.18	19.7

WHEAT						
Seed Date	Acc GDD	Grwth Stage	Day	3day	7day	Seas. in.
			-----in/d----			
08/15	1615	Tiller	.11	.11	.10	4.7
09/10	651	Emerged	.11	.11	.10	1.6
10/01	27	Seeded	.07	.02	.01	0.1

If you note unusual or inconsistent numbers, or do not recieve the fax, please call:

Leon New at 806-359-5401.

Figure 2. PET fax output of October 1, 1995 for Etter, TX as presented to the subscriber in English units.

of October 1, 1995, is illustrated in Fig. 3. The BBS utilizes a menu driven system to navigate through the system. This method allows discipline and informational avenues to be pursued. In addition, the BBS under the weather menu contains seasonal summary information as well as some historical records for the longer established locations.

RESULTS AND FORECAST

The 1995 summer season proved to be challenging for the development and implementation teams, but the PET network was successful in disseminating approximately 27,000 faxes during the corn and grain sorghum seasons. The system outputs are intended to be available to subscribers before 7:00 a.m. each day, and this was generally achieved throughout the seasons. As additional users are enrolled, dissemination capabilities of the system will have to be expanded to meet this requirement. Possible solutions are disseminating faxes in a simultaneous, split fashion by multiple PC computers or moving to a multitasking environment. Fully compatible, automatic interrogation software is not currently available for the acquisition processes of the network.

Station:ETTER, TX Long 102 deg 40 min Lat 36 deg 0 min
Date: 10/01/95 Year/DOY: 95274
Sunrise 644 Sunset 1833 Daylight time = 11 hours 49 minutes

Time CST	Rs W/m^2	Ts2 C	Ts6 C	Tair C	TDew C	RH %	VP kPa	VPD kPa	WSpd m/s	Wdir deg	SDd deg	PREC mm
100	-0.0	15.0	18.4	7.8	5.6	86	0.91	0.15	1.2	223	9	0.00
200	-0.0	14.5	18.1	7.5	5.5	87	0.91	0.13	1.2	221	9	0.00
300	-0.1	14.1	17.8	7.1	5.3	89	0.89	0.11	1.4	216	8	0.00
400	-0.1	13.8	17.6	7.0	5.3	89	0.89	0.11	1.5	213	8	0.00
500	-0.0	13.4	17.3	6.9	5.3	89	0.89	0.11	2.0	204	8	0.00
600	-0.1	13.1	17.1	6.8	5.2	90	0.89	0.10	2.0	212	13	0.00
700	2.6	12.8	16.9	5.4	4.5	94	0.84	0.05	1.2	222	12	0.00
800	36.9	12.6	16.7	7.8	6.2	90	0.95	0.11	2.3	228	12	0.00
900	319.9	12.9	16.5	12.7	8.2	74	1.09	0.38	3.2	233	16	0.00
1000	513.1	14.4	16.3	16.4	8.0	58	1.07	0.80	5.0	218	13	0.00
1100	669.0	16.7	16.2	19.1	7.1	46	1.01	1.21	5.8	215	13	0.00
1200	771.5	18.7	16.4	20.3	6.2	40	0.95	1.44	6.2	211	13	0.00
1300	815.4	20.5	16.6	21.6	6.4	37	0.96	1.62	6.0	212	14	0.00
1400	797.6	22.1	17.0	22.9	6.1	34	0.94	1.85	6.1	203	15	0.00
1500	702.7	23.6	17.4	24.0	6.1	32	0.94	2.03	5.7	202	17	0.00
1600	560.8	23.4	17.9	24.5	6.4	31	0.96	2.11	6.1	199	16	0.00
1700	384.1	22.2	18.3	24.4	6.7	32	0.98	2.07	6.0	203	13	0.00
1800	156.9	20.9	18.6	23.2	6.9	35	0.99	1.85	5.7	197	12	0.00
1900	20.8	19.7	18.7	21.2	7.1	40	1.01	1.51	3.7	183	16	0.00
2000	-0.0	18.6	18.7	18.3	7.1	48	1.01	1.10	3.3	168	22	0.00
2100	-0.0	17.8	18.6	16.9	7.4	53	1.03	0.90	3.8	174	21	0.00
2200	-0.0	17.1	18.5	15.7	7.4	58	1.03	0.76	3.4	177	21	0.00
2300	-0.0	16.6	18.3	15.0	7.6	61	1.04	0.66	2.9	177	19	0.00
2400	-0.0	16.2	18.1	13.1	7.7	70	1.05	0.45	1.3	49	27	0.00
Sum	20.7 MJ											0.00
Avg		17.1	17.6	15.2	6.5	61	0.97	0.90	3.62	204	32	
Max	823.4	23.9	18.7	24.7	9.5	96	1.19	2.18	10.20			
Time	1302	1451	1852	1534	858	703	858	1511	1054			
Min		12.6	16.2	4.9	4.1	29	0.82	0.03				
Time		727	1025	649	638	1448	638	703				

Figure 3. PET hourly file on bulletin board system for October 1, 1995 for Etter,TX

Slight adjustments were made processing files during the seasons to adjust accumulated growing degree day units to match the physiological growth stages. Data regarding these developments was not complete when the network was initialized.

We estimate that using the PET network could reduce water use by a minimum of 50 mm for a typical crop such as corn or wheat. Based on current fuel costs, which are low, the value of that 50 mm reduction alone regionwide would exceed 18 million dollars. Several progressive irrigators reported achieving this water use reduction without sacrificing yield. In addition, the network proved to be valuable in determining peak ET periods and avoiding yield reductions when compared to typical methods of irrigation scheduling. Crop consultants used the ET values in scheduling irrigation throughout the 1995 season with good results.

Refinement of physiological growth stage and heat unit threshold data continues at the research locations of Etter and Bushland, TX. The lysimetry facility at the ARS research laboratory, under the direction of Dr. Terry Howell, continues to refine crop coefficients for field crops, especially those not calibrated thus far within the region. One example of such a crop is sugarbeets.

The response to the network within the region and the state has been positive. The network outputs were available on a fee-wavered basis during 1995 and are similarly offered 1996 to allow more familiarity with the concept and the network for irrigation scheduling and for educational and training use. Network availability on the internet will be available when compatible, automated upload software is installed.

Currently, another underground water conservation district in the Texas Panhandle and a commodity organization are proposing additional weather stations to provide accurate ET data within their area. Two likely additions in mid 1996 are near Perryton, TX (northeastern most point) and Quail, TX, (most central eastern point) in Fig. 1. Additional weather station requests will be considered and evaluated based on criteria mentioned earlier in the development plan. Another PET network within the southern region of Texas is under development in conjunction with the Lower Colorado River Authority. It uses the protocols and methodology developed from this network and results have also been good.

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